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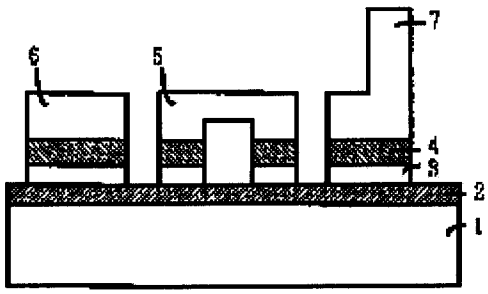
(54) INSULATING MATERIAL COMPOSITION AND CIRCUIT BOARD AND MODULE USING THIS INSULATING MATERIAL COMPOSITION

(57)Abstract:

PURPOSE: To provide an insulating material composition for a metal base circuit board, having high heat conductivity and low dielectric constant, further capable of maintaining high electric insulation over a long period, by hardening a mixture composed of inorganic filling material and resin.



CONSTITUTION: By hardening a mixture composed of inorganic filling material and resin, an insulating material composition, having 3.0×10-3cal/cm.sec, °C or more heat conductivity further with 4.5 or less dielectric constant, is obtained. As the inorganic filling material, containing one kind or more of boron nitride, diamond and beryllium oxide, is preferable, particularly containing hexagonal system boron nitride of 2.0 or less graphitization (GI value) is preferable. The inorganic filling material is preferable high filled, and its shape is preferable a sphere of about 15μm or less. In the resin, epoxy resin, silicone resin, etc., are used. This insulating material composition is used, to provide an insulating layer 2 on a metal plate 1 of Al or the like, to laminate conductive foil 3 on this layer, to form a circuit board, further to mount each element 5 to 7, so as to obtain a module.

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CLAIMS

[Claim(s)]
[Claim 1] The insulating material constituent characterized by making it come to harden the mixture which consists of an inorganic filler and resin, for the thermal conductivity being more than 3.0x10-3 cal/cm-sec and **, and moreover specific inductive capacity being 4.5 or less.
[Claim 2] The insulating material constituent according to claim 1 with which an inorganic filler contains one sort in boron nitride, a diamond, and beryllium oxide, or two sorts or more.
[Claim 3] The insulating material constituent according to claim 1 with which an inorganic filler is characterized by a degree of graphitization (GI value) containing 2.0 or less hexagonal boron nitride.
[Claim 4] The circuit board which comes to carry out the laminating of the electric conduction foil to a metal plate through an insulating material constituent according to claim 1, 2, or 3.
[Claim 5] The module which comes to use the circuit board according to claim 4.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the metal base circuit board using the insulating material constituent and this which are used for electronic parts, such as an electrical machinery and apparatus, a transmitter, and an automotive application, and the module using this further.
[0002]
[Description of the Prior Art] High temperature conduction and the insulating material of high withstand voltage are demanded of the application of the electron of the metal base circuit board, a semiconductor device, and others, the sealing agent of an electrical part, adhesives, or a potting agent. For example, since the metal base circuit board is used for the high power field, engine performance, such as high electric insulation and high temperature conductivity, is required of the insulating layer of the substrate. Furthermore, RF-ization of a circuit is progressing for the purpose of the miniaturization of a circuit, and advanced features, and the circuit board with low specific inductive capacity and an insulating material for it are desired. Especially, power components, such as an IGBT component, come to be carried in recent years, with the low dielectric constant, it has high electric insulation, and the metal base circuit board which moreover has high temperature conductivity is required, and the insulating material constituent for forming the insulating layer is needed.
[0003] In the metal base circuit board, although a metal plate and an electric conduction foil are pasted up with the adhesives of electric insulation which consist of resin filled up with the aluminum oxide etc., the insulating material which these adhesives hardened forms the insulating layer on a metal plate. Since many properties of the metal base circuit board are greatly influenced by the property of an insulating layer, therefore an insulating material, various constituents have been indicated.
[0004] For example, it having been high-filled up with the inorganic filler and the insulating adhesives constituent for the circuit boards with high thermal conductivity having been obtained, and having carried out the laminating of a metal substrate and the electric conduction foil through the adhesives constituent, and having obtained the circuit board is indicated by JP,2-286768,A by using the inorganic filler of specific particle diameter.
[0005] Moreover, the bisphenol A mold epoxy resin of 90% or more of purity is filled up with an aluminum oxide, alumimium nitride, and the inorganic filler of boron nitride, and the circuit board using the insulating material and it whose thermal conductivity is 5.0x10-3 - 18.0x10-3 cal/cm-sec and ** and whose glass transition temperature is 164-240 degrees C is indicated by JP,6-44824,A.
[0006]
[Problem(s) to be Solved by the Invention] However, in the insulating material which consists of resin high-filled up with matter of high specific inductive capacity like an aluminum oxide (specific inductive capacity 9.0), the specific inductive capacity of an insulating material becomes high as the fill of an inorganic filler increases. Moreover, since viscosity became high at this and coincidence and the contamination of a void increased, there was a problem that electric insulation fell and a withstand voltage property fell.

[0007] Since the high voltage is impressed to a void so that the specific inductive capacity of an insulating material is high, the electrical potential difference generally built over the void which exists in a layer-like insulating material becomes easy to discharge by the void. For this reason, the electric insulation of the circuit board using an insulating layer, therefore this tends to fall, so that the specific inductive capacity of a filler is high.
[0008] Moreover, it is known that electric insulation will deteriorate gradually under the service condition, and the circuit board will finally result a dielectric-breakdown phenomenon in a lifting life. a discharge phenomenon with how partial inside insulating layers, such as a void, at that initial stage depending on which degradation of electric insulation progresses -- presenting -- this partial discharge -- degradation of an insulating layer -- promoting -- just -- being alike -- the discharge phenomenon of passing an insulating layer is caused and it results in dielectric breakdown. Therefore, in order to attain the long-term dependability of electric insulation, it is important to make breakdown voltage high.
[0009] In the conventional metal base circuit board, high temperature conductivity was thought as important and the aluminum oxide with specific inductive capacity high as an inorganic filler was mainly used. Or even if it thought electric insulation as important, and it did not add an inorganic filler or it added, it had limited to restoration of a little chisel. Although the former had high temperature conductivity, electric insulation is low, ****** dependability was inferior in it, and by the latter, although excelled in electric insulation, since thermal conductivity was inferior, it was not able to be used for the application of which high heat dissipation nature is required. Thus, having dependability high electric insulation and over a long period of time [its] had the problem of being difficult, maintaining high temperature conductivity.
[0010] The purpose of this invention is to offer the insulating material constituent used for the metal base circuit board which is high temperature conductivity and can maintain high electric insulation over a long period of time.
[0011] Moreover, even if this invention carries the component of high power by high density, it aims at excelling in heat leakage nature, excelling in electric insulation, and offering the reliable circuit board and a reliable module.
[0012]
[Means for Solving the Problem] This invention is an insulating material constituent characterized by making it come to harden the mixture which consists of an inorganic filler and resin, for the thermal conductivity being more than 3.0x10-3 cal/cm-sec and **, and moreover specific inductive capacity being 4.5 or less.
[0013] Moreover, this invention is an insulating material constituent characterized by this inorganic filler containing one sort in boron nitride, a diamond, and beryllium oxide, or two sorts or more.
[0014] Moreover, this invention is an insulating material constituent with which this inorganic filler is characterized by a degree of graphitization (GI value) containing 2.0 or less hexagonal boron nitride.
[0015] Furthermore, this invention is the circuit board which comes to carry out the laminating of the electric conduction foil through the insulating material constituent whose thermal conductivity is more than 3.0x10-3 cal/cm-sec and **, and whose specific inductive capacity is moreover 4.5 or less, in addition is a module which comes to use this circuit board.
[0016] Hereafter, a drawing explains this invention to a detail. The sectional view of the module using the metal base circuit board which comes to form an insulating layer with the insulating material constituent of this invention is shown in drawing 1 . After obtaining the metal base circuit board by which the laminating of the electric conduction foil 3 was carried out on the metal plate 1 through the insulating layer 2 which consists of an insulating material constituent of this invention, etching etc. was processed and it is made of the configuration which carried out the laminating of the ceramic chip 5, a semiconductor device 6, and the terminal 7 grade through the pewter 4.
[0017] The aluminum and an aluminium alloy, copper, iron, a stainless steel system alloy, the Invar system multilevel metal, etc. of about 0.5-3.0mm of board thickness are used for a metal plate 1 here.
[0018] An insulating layer 2 is the insulating material constituent which mixes and stiffened an inorganic filler and resin, and, moreover, thermal conductivity is [specific inductive capacity] 4.5 or

less 3.0x10-3 cal/cm-sec and above **. If the specific inductive capacity of an insulating layer 2 exceeds 4.5, breakdown voltage will fall extremely, it will become easy to produce discharge degradation, and the long-term dependability of the electric insulation of the circuit board will be spoiled remarkably. About thermal conductivity, the heat generated from a power component as they are under 3.0x10-3 cal/cm-sec and ** cannot be emitted efficiently, but the temperature of a component exceeds junction temperature (about 150 degrees C), a component malfunctions or a life becomes short.

[0019] As resin used for the insulating material constituent which forms an insulating layer 2, an epoxy resin, silicone resin, BT resin, polyimide resin, etc. are used. As an epoxy resin, it is hypoviscosity, and the bisphenol A mold epoxy resin and the bisphenol female mold epoxy resin fit high restoration of an inorganic filler, and are desirable. Although especially the thickness of an insulating layer 2 is not specified, when the balance of a breakdown voltage and thermal resistance is taken into consideration, 20-500 micrometers is desirable.

[0020] Moreover, as for the inorganic filler used for the insulating material constituent which forms an insulating layer 2, it is indispensable that it is the matter with low specific inductive capacity. Thermal conductivity is more than 3.0x10-3 cal/cm-sec and **, and in order to obtain the insulating material constituent whose specific inductive capacity is moreover 4.5 or less, beryllium oxide, a diamond, and boron nitride are chosen. When economical efficiency or safety is taken into consideration, boron nitride is the industrial most suitable inorganic filler. Moreover, as long as the thermal conductivity and specific inductive capacity of the request made into the purpose are obtained including these one sort or two sorts or more, you may use together with inorganic fillers, such as other aluminas.

[0021] About the particle diameter of these inorganic fillers, 15 micrometers or less are desirable. If 15 micrometers is exceeded, it becomes, or into the insulating layer after hardening, a void tends to remain, and comes [BUTSU] being easy to generate in mixing with resin, decline in thermal conductivity and the fall of electric insulation arise, and a desired insulating material cannot be obtained. If it is 15 micrometers or less, the debris of a sintered compact etc. can be used like the usual powder. Moreover, about particle shape, in order to raise thermal conductivity, it is desirable to be high-filled up with an inorganic filler, and the thing of the configuration near a ball is desirable.

[0022] As said boron nitride, although various things, such as h-BN, P-BN, c-BN, and t-BN, are used, it is also possible to mix and use these. It belongs to hexagonal system, and electric insulation is high and it is [especially h-BN is the raw material which can come to hand cheaply, and] desirable. The crystallinity of hexagonal boron nitride is shown by the degree of graphitization (GI value) as the standard. GI value is computed by the formula (1) from the diffraction reinforcement (peak area) of the field by the X diffraction (100) (101) (102).

[0023]

[Equation 1]

GI value =(100) (area + (101) area)/(102) (area) .... (1)

[0024] Crystallinity is so high that GI value is small. GI value is set to 1.4 by the hexagonal boron nitride to which crystallization progressed completely. Although 2.0 or less are desirable as for the crystallinity of the hexagonal boron nitride used by this invention, it is 1.6 or less more preferably. Generally the hexagonal boron nitride to which a degree of graphitization exceeds 2.0 has low purity, gas is generated at the time of mixing with resin, and the problem that thermal conductivity is low occurs low [electric insulation-proof] that it is easy to involve in a void.

[0025] In order to raise the adhesive property of the interface of resin and boron nitride, as for the aforementioned boron nitride, what performed surface treatment with the silicone coupling agent, the titanate coupling agent, the sililation reagent, etc. is good. What performed surface treatment with the organic silane compound among these is more desirable. Moreover, the surface treatment of the boron nitride by the finishing agent is possible also by adding a finishing agent at the time of mixing of resin and boron nitride.

[0026] Although less than [more than 40vol%85vol%] is good as for the blending ratio of coal of boron nitride, it is less than [more than 50vol%70vol%] preferably. The thermal conductivity of the insulating material constituent with which the blending ratio of coal of boron nitride is obtained less than

[40vol%] does not reach 3.0x10-3 cal/cm-sec and **. Elastic resin mixture is not obtained, but since the hardened material is also in the condition of BOROBORO, it may stop on the other hand, attaining the purpose of this invention, even if it performs the aforementioned surface preparation when 85vol% is exceeded. In the case of not more than more than 50vol%70vol%, it is high temperature conductivity, and the insulating material constituent which was moreover able to balance low specific inductive capacity can be stabilized and manufactured.

[0027] the electric conduction foil 3 -- a conductor -- general-purpose things, such as a clad foil which used the alloy containing two or more kinds of metals, such as copper foil for circuits, a compound foil or copper, aluminum, and nickel, or said metal, are used. The thickness is 1mm from 5 micrometers. Moreover, in order to give a wire-bonding property, nickel plating and nickel-gold plate may be performed on an electric conduction foil.

[0028]

[Function and Example(s)] Hereafter, an example is explained concretely.

(Example 1) The boron nitride powder which mixed boron nitride powder (the DENKI KAGAKU KOGYO K.K. make, GPS-2) with hexamethyldisilazane (Toshiba Silicone make), and carried out silanizing processing was produced. this boron nitride powder that carried out silanizing processing -- an inorganic filler -- carrying out -- a bisphenol female mold epoxy resin -- 61vol(s)% -- the filled mixture was produced. The thermal conductimetry and specific-inductive-capacity measurement which are shown below were performed about the hardened material which added and carried out heat hardening of the amine system curing agent to this mixture, and obtained it into it. Next, said mixture was applied to the aluminum plate of 1.5mm thickness, the layer with a thickness of 100 micrometers was formed, and the metal base circuit board was further produced by carrying out the laminating of the copper foil with a thickness of 35 micrometers, and heating it on it. The breakdown voltage measurement shown below and the rise thermometry at the time of energization of a transistor were performed using this circuit board. Moreover, in order to investigate the dielectric-breakdown life of the circuit board, measurement of a V-t property was repeated and it carried out by 20 numbers. The obtained result is shown in Table 1.

[0029] It measured by filter;100Hz ATT range;20microvolt and sampling rate;1000 microsecond using the test piece of a disk form with a 2mm[in <measuring method of thermal conductivity> thickness] x diameter of 10mm by laser flash method thermal conductivity measuring apparatus ("LF/TCM-FA-8510B" by Rigaku Industrial Corp.).

[0030] Based on the <measuring method of specific inductive capacity> JIS C 6481, it carried out at the test frequency of 100kHz, and the measurement temperature of 25 degrees C.

[0031] On the metal base substrate of which <measuring method of breakdown voltage> production was done, the diameter produced the circle electrode pattern which is 20mm by the etching method. The breakdown voltage between the base metal section and the pattern section was measured by 100kHz of test frequencies with the partial discharge measuring instrument (Mitsubishi Cable Industries, Ltd., QM-20).

[0032] The electric conduction foil of a <measuring method of transistor rise temperature> metal base substrate was etched, the 10x15mm pad section was formed, and the transistor (TO-220, Toshiba Make) was soldered on this. Cooling a metal plate surface side, it energized 100W to the transistor and the temperature on the top face of a transistor was measured.

[0033] On the <measuring method of V-t property> metal base substrate, by the etching method, the circle electrode pattern whose diameter is 20mm was produced, and the electrical potential difference of 2kV of AC half waves was impressed between the base metal section and the pattern section. Measurement was performed under the 125-degree C environment, in order to promote a trial. Time amount until it results [from electrical-potential-difference impression initiation] in dielectric breakdown was measured, and average life was computed by the Weibull plotting method.

[0034] (Examples 2-9, examples 1-4 of a comparison) As an inorganic filler, the boron nitride of commercial various grain size, a diamond, beryllium oxide, an aluminum oxide, etc. were prepared, by the blending ratio of coal shown in Table 1, by the same approach as an example 1, the hardened

material of various kinds of insulating material constituents was produced, and thermal conductivity and specific inductive capacity were measured. In addition, what does not perform surface treatment was produced in some things. Furthermore, the circuit board was produced using said insulating material constituent, and breakdown voltage measurement, a transistor rise thermometry, and V-t property measurement were performed like the example 1. A result is shown in Table 1 with the result of an example 1.

[0035]

[Table 1]

	No	樹脂の種類	無機充填材				表面処理剤	熱伝導率	比誘電率	放電開始電圧	平均破壊時間	トランジスター温度
			種類	GI値	平均粒径	充填率						
		-	-	-	μm	vol%	-	$\times 10^{-3}$ cal/cm·sec·℃	-	kV	Hr.	℃
実施例	1	ビスフェノールF型エポキシ樹脂	窒化硼素	1.4	3.5	61	ヘキサメチルジシラザン	9.1	4.2	2.2	>10000	71
	2	ビスフェノールA型エポキシ樹脂	窒化硼素	1.6	3.5	55	エポキシシリコーン	7.0	4.1	2.2	>10000	79
	3	ビスフェノールF型エポキシ樹脂	窒化硼素	1.4	4.0	50	エポキシシリコーン	4.5	4.0	2.3	>10000	129
	4	ビスフェノールF型エポキシ樹脂	窒化硼素	1.5	3.0	45	エポキシシリコーン	3.0	3.9	2.4	>10000	145
	5	ビスフェノールF型エポキシ樹脂	ダイアモンド	-	1.2	50	-	9.0	4.4	2.1	>10000	74
	6	ビスフェノールF型エポキシ樹脂	酸化ベリリウム	-	2.1	65	-	18.2	4.5	2.1	>10000	49
	7	ビスフェノールF型エポキシ樹脂	窒化硼素	2.0	8.7	72	エポキシシリコーン	16.5	4.3	2.2	>10000	55
	8	ビスフェノールF型エポキシ樹脂	窒化硼素	1.8	13.6	81	アミノシラン	31.1	4.4	2.1	>10000	40
	9	ビスフェノールF型エポキシ樹脂	窒化硼素 * +酸化ベリリウム	-	-	74	-	25.4	4.5	2.1	>10000	44
比較例	1	ビスフェノールF型エポキシ樹脂	酸化硅素	-	5.0	70	エポキシシリコーン	2.2	3.7	2.5	>10000	>150
	2	ビスフェノールF型エポキシ樹脂	酸化アルミニウム	-	14.6	73	-	8.9	7.6	1.2	2100	75
	3	ビスフェノールF型エポキシ樹脂	窒化硼素	3.5	3.5	35	-	1.3	3.8	2.2	>10000	>150
	4	ビスフェノールF型エポキシ樹脂	窒化硅素	-	4.5	58	エポキシシリコーン	4.9	5.6	1.7	2900	119

*窒化硼素：酸化ベリリウム＝1：1（体積比）

[0036]

[Effect of the Invention] According to this invention, the circuit board and the module thermal conductivity was high, and the insulating material constituent specific inductive capacity moreover excelled [constituent] in electric insulation low was obtained, and breakdown voltage excelled [module] in dependability highly over a long period of time were able to be obtained. The insulating material constituent of this invention has high thermal conductivity, and since specific inductive capacity is moreover low, it is suitable also as a sealing agent of a semiconductor device.

[0037]

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TECHNICAL FIELD

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PRIOR ART

[Description of the Prior Art] High temperature conduction and the insulating material of high withstand voltage are demanded of the application of the electron of the metal base circuit board, a semiconductor device, and others, the sealing agent of an electrical part, adhesives, or a potting agent. For example, since the metal base circuit board is used for the high power field, engine performance, such as high electric insulation and high temperature conductivity, is required of the insulating layer of the substrate. Furthermore, RF-ization of a circuit is progressing for the purpose of the miniaturization of a circuit, and advanced features, and the circuit board with low specific inductive capacity and an insulating material for it are desired. Especially, power components, such as an IGBT component, come to be carried in recent years, with the low dielectric constant, it has high electric insulation, and the metal base circuit board which moreover has high temperature conductivity is required, and the insulating material constituent for forming the insulating layer is needed.
[0003] In the metal base circuit board, although a metal plate and an electric conduction foil are pasted up with the adhesives of electric insulation which consist of resin filled up with the aluminum oxide etc., the insulating material which these adhesives hardened forms the insulating layer on a metal plate. Since many properties of the metal base circuit board are greatly influenced by the property of an insulating layer, therefore an insulating material, various constituents have been indicated.
[0004] For example, it having been high-filled up with the inorganic filler and the insulating adhesives constituent for the circuit boards with high thermal conductivity having been obtained, and having carried out the laminating of a metal substrate and the electric conduction foil through the adhesives constituent, and having obtained the circuit board is indicated by JP,2-286768,A by using the inorganic filler of specific particle diameter.
[0005] Moreover, the bisphenol A mold epoxy resin of 90% or more of purity is filled up with an aluminum oxide, alumimium nitride, and the inorganic filler of boron nitride, and the circuit board using the insulating material and it whose thermal conductivity is 5.0x10-3 - 18.0x10-3 cal/cm-sec and ** and whose glass transition temperature is 164-240 degrees C is indicated by JP,6-44824,A.

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EFFECT OF THE INVENTION

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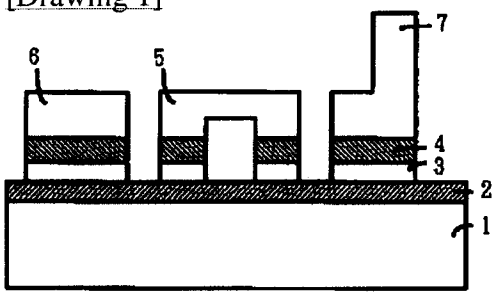
DRAWINGS

[Drawing 1]



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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view of the module using the metal base circuit board of this invention.
1. Metal Plate
2. Insulating Layer
3. Electric Conduction Foil
4. Pewter
5. Ceramic Chip
6. Semiconductor Device
7. Terminal

[Translation done.]

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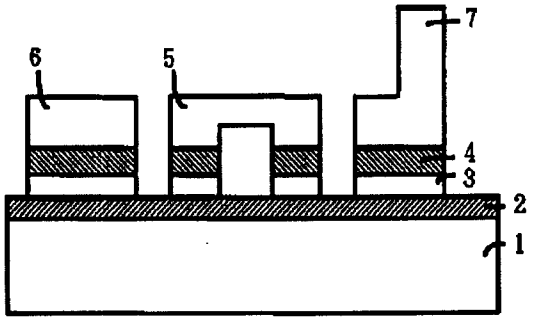
(54)【発明の名称】　絶縁材料組成物及びそれを用いた回路基板とモジュール

(57)【要約】

【目的】　電気機器、通信機、自動車用途などの電子部品に用いられる高熱伝導性でしかも高電気絶縁性を長期に渡り維持し得る絶縁材料組成物と、これを用いた金属ベース回路基板、更にこれを用いたモジュールを提供すること。

【構成】　無機充填材と樹脂からなる混合物を硬化させてなり、その熱伝導率が3.0×10^{-3} cal/cm･sec･℃以上であり、しかも比誘電率が4.5以下である絶縁材料組成物を構成とする。又、この絶縁材料組成物を用いた金属ベース回路基板、更に、この金属ベース回路基板を用いたモジュールである。

【効果】　本発明の絶縁材料組成物は熱伝導率が高く、しかも比誘電率が低いので、これを用いた金属ベース回路基板及びモジュールは、放電開始電圧が高く長期に渡り電気絶縁性が維持でき、信頼性が高い。



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【特許請求の範囲】

【請求項1】　無機充填材と樹脂からなる混合物を硬化させてなり、その熱伝導率が3.0×10^{-3}cal/cm・sec・℃以上であり、しかも比誘電率が4.5以下であることを特徴とする絶縁材料組成物。

【請求項2】　無機充填材が、窒化硼素、ダイアモンド、酸化ベリリウムのうちの1種又は2種以上を含む請求項1記載の絶縁材料組成物。

【請求項3】　無機充填材が、黒鉛化度（GI値）が2.0以下の六方晶窒化硼素を含むことを特徴とする請求項1記載の絶縁材料組成物。

【請求項4】　金属板に請求項1、2又は3記載の絶縁材料組成物を介して導電箔を積層してなる回路基板。

【請求項5】　請求項4記載の回路基板を用いてなるモジュール。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は電気機器、通信機、自動車用途などの電子部品に用いられる絶縁材料組成物とこれを用いた金属ベース回路基板、更にこれを用いたモジュールに関するものである。

【0002】

【従来の技術】金属ベース回路基板、半導体素子その他の電子、電気部品の封止材、接着剤或いはポッティング剤の用途に高熱伝導、高耐電圧の絶縁材料が要求されている。例えば、金属ベース回路基板は、ハイパワー分野に使用されるため、その基板の絶縁層には、高電気絶縁性及び高熱伝導性といった性能が要求される。更に、回路の小型化、高機能化を目的に回路の高周波化が進んでおり、比誘電率の低い回路基板及びそのための絶縁材料が望まれている。特に、近年IGBT素子等のパワー素子が搭載されるようになり、低誘電率で、高電気絶縁性を有し、しかも高熱伝導性を兼ね備えている金属ベース回路基板が要求され、その絶縁層を形成するための絶縁材料組成物が必要とされている。

【0003】金属ベース回路基板においては、酸化アルミニウム等を充填した樹脂からなる電気絶縁性の接着剤にて金属板と導電箔とを接着するが、この接着剤が硬化した絶縁材料は金属板上に絶縁層を形成している。金属ベース回路基板の諸特性は絶縁層、従って絶縁材料の特性に大きく左右されるので、いろいろな組成物が開示されてきた。

【0004】例えば、特開平2－286768号公報には、特定の粒子径の無機充填材を用いることにより、無機充填材を高充填することができ、熱伝導率が高い回路基板用絶縁接着剤組成物が得られ、その接着剤組成物を介して金属基板と導電箔とを積層し回路基板を得ていることが開示されている。

【0005】また、特開平6－44824号公報には、純度90%以上のビスフェノールA型エポキシ樹脂に酸化

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アルミニウム、窒化アルミニウム、窒化硼素の無機充填材を充填し、熱伝導率が5.0×10^{-3}～18.0×10^{-3}cal/cm・sec・℃であり、かつガラス転移温度が164～240℃である絶縁材料とそれを用いた回路基板が開示されている。

【0006】

【発明が解決しようとする課題】しかし、酸化アルミニウム（比誘電率9.0）のような高比誘電率の物質を高充填した樹脂からなる絶縁材料に於いては、無機充填材の充填量が多くなるにつれて、絶縁材料の比誘電率が高くなる。またこれと同時に粘度が高くなりボイドの巻き込みが多くなるため、電気絶縁性が低下し耐電圧特性が低下するという問題があった。

【0007】一般的に、層状の絶縁材料中に存在するボイドにかかる電圧は、絶縁材料の比誘電率が高いほどボイドに高電圧が印加されるので、ボイドで放電し易くなる。このため、充填材の比誘電率が高いほど、絶縁層従ってこれを用いた回路基板の電気絶縁性は低下しやすい。

【0008】また、回路基板は、その使用条件下で次第に電気絶縁性が劣化して最終的には絶縁破壊現象を起こし寿命に至ることが知られている。電気絶縁性の劣化の進み方は、その初期段階でボイド等の絶縁層内部で部分的な放電現象を呈し、この部分的な放電が絶縁層の劣化を促進し、ついには絶縁層を通過する放電現象を引き起こし絶縁破壊に至る。従って、電気絶縁性の長期信頼性を達成するには、放電開始電圧を高くすることが大切である。

【0009】従来の金属ベース回路基板では、高熱伝導性を重視して無機充填材として比誘電率の高い酸化アルミニウムを主に用いていた。もしくは電気絶縁性を重視して無機充填材を添加しないか、もしくは添加しても少量のみの充填にとどめていた。前者は高熱伝導性を有するが電気絶縁性が低くく長期信頼性が劣り、後者では電気絶縁性に優れるが熱伝導性が劣るので高放熱性を要求される用途には利用できなかった。このように、高熱伝導性を維持しながら、高電気絶縁性とその長期信頼性を兼備することは難しいという問題があった。

【0010】本発明の目的は、高熱伝導性で、かつ、高電気絶縁性を長期に渡り維持できる金属ベース回路基板等に用いる絶縁材料組成物を提供することにある。

【0011】また、本発明は、高出力の素子を高密度で搭載しても、熱放散性に優れ、電気絶縁性に優れ信頼性の高い回路基板及びモジュールを提供することを目的とする。

【0012】

【課題を解決するための手段】本発明は、無機充填材と樹脂からなる混合物を硬化させてなり、その熱伝導率が3.0×10^{-3}cal/cm・sec・℃以上であり、しかも比誘電率が4.5以下であることを特徴とする絶縁材料組成物である。

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【００１３】又、本発明は、該無機充填材が窒化硼素、ダイアモンド、酸化ベリリウムのうちの１種又は２種以上を含むことを特徴とする絶縁材料組成物である。

【００１４】又、本発明は、該無機充填材が黒鉛化度（ＧＩ値）が2.0以下の六方晶窒化硼素を含むことを特徴とする絶縁材料組成物である。

【００１５】更に、本発明は、熱伝導率が3.0×10^{-3}cal/cm･sec･℃以上であり、しかも比誘電率が4.5以下である絶縁材料組成物を介して導電箔を積層してなる回路基板であり、加えて、該回路基板を用いてなるモジュールである。

【００１６】以下、図面により本発明を詳細に説明する。本発明の絶縁材料組成物で絶縁層を形成してなる金属ベース回路基板を用いたモジュールの断面図を図１に示す。金属板１上に、本発明の絶縁材料組成物よりなる絶縁層２を介して導電箔３が積層された金属ベース回路基板を得た後、エッチング等の処理を施し、セラミックスチップ部品５、半導体素子６、端子７等をハンダ４を介して積層した構成からできている。

【００１７】ここで金属板１には、板厚0.5～3.0mm程度のアルミニウム及びアルミニウム合金、銅、鉄、ステンレス系合金及びインバー系多層金属等が用いられる。

【００１８】絶縁層２は、無機充填材と樹脂を混合し硬化させた絶縁材料組成物であり、熱伝導率が3.0×10^{-3}cal/cm･sec･℃以上でしかも比誘電率が4.5以下である。絶縁層２の比誘電率が4.5を越えると、放電開始電圧が極端に低下して放電劣化が生じ易くなり、回路基板の電気絶縁性の長期信頼性が著しく損なわれる。熱伝導率については、3.0×10^{-3}cal/cm･sec･℃未満であるとパワー素子から発生する熱を効率よく放出することができず、素子の温度がジャンクション温度(約150℃)を越え、素子が誤動作したり寿命が短くなる。

【００１９】絶縁層２を形成する絶縁材料組成物に使用される樹脂としては、エポキシ樹脂、シリコーン樹脂、ＢＴレジン、ポリイミド樹脂等が用いられる。エポキシ＊

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＊樹脂としては、ビスフェノールＡ型エポキシ樹脂、ビスフェノールＦ型エポキシ樹脂が低粘度であり、無機充填材の高充填に適しており、好ましい。絶縁層２の厚みについては特に規定するものでないが、絶縁破壊電圧と熱抵抗とのバランスを考慮すると20～500μmが好ましい。

【００２０】又、絶縁層２を形成する絶縁材料組成物に使用される無機充填材は、比誘電率の低い物質であることが必須である。熱伝導率が3.0×10^{-3}cal/cm･sec･℃以上であり、しかも比誘電率が4.5以下である絶縁材料組成物を得るためには、酸化ベリリウム、ダイアモンド、窒化硼素が選択される。経済性または安全性を考慮すると窒化硼素が工業的に最も好適な無機充填材である。又、これらの１種又は２種以上を含み、目的とする所望の熱伝導率と比誘電率が得られれば、他のアルミナ等の無機充填材と併用しても良い。

【００２１】これらの無機充填材の粒子径については、15μm以下が好ましい。15μmを越えると、樹脂との混合においてブツが発生し易くなったり、硬化後の絶縁層中にボイドが残留し易くなり、熱伝導率の低下や電気絶縁性の低下が生じ所望の絶縁材料を得られない。15μm以下であれば、焼結体の破砕物等も、通常の粉末と同様に用いることができる。又、粒子形状については、熱伝導率を向上させるために無機充填材を高充填することが望ましく、球に近い形状のものが好ましい。

【００２２】前記窒化硼素としては、h-BN,P-BN,c-BN,t-BN等いろいろなものが用いられるが、これらを混合して用いることも可能である。特にh-BNは六方晶系に属し電気絶縁性が高く、安価に入手できる原料であり好ましい。六方晶窒化硼素の結晶性は、その目安として黒鉛化度（ＧＩ値）で示される。ＧＩ値は、Ｘ線回折による（１００）（１０１）（１０２）面の回折強度(ピーク面積)より、式（１）で算出したものである。

【００２３】

【数１】

$$GI値=((100)面積+(101)面積)/((102)面積)\cdots\cdots(1)$$

【００２４】ＧＩ値の小さいほど、結晶性が高い。完全に結晶化が進んだ六方晶窒化硼素でＧＩ値は1.4となる。本発明で用いる六方晶窒化硼素の結晶性は、2.0以下が好ましいが、より好ましくは1.6以下である。黒鉛化度が2.0を越える六方晶窒化硼素は、一般的に純度が低く、樹脂との混合時にガスを発生してボイドを巻き込み易く耐電気絶縁性が低い、もしくは熱伝導性が低いという問題が発生する。

【００２５】前記の窒化硼素は、樹脂と窒化硼素の界面の接着性を高めるために、シリコーンカップリング剤、チタネートカップリング剤、シリル化剤等にて表面処理を施したものが良い。これらのうち有機シラン化合物で表面処理を施したものがより好ましい。また、表面処理剤による窒化硼素の表面処理は、樹脂と窒化硼素の混合時に表面処理剤を添加することによっても可能である。

【００２６】窒化硼素の配合割合は、40vol%以上85vol%以下が良いが、好ましくは50vol%以上70vol%以下である。窒化硼素の配合割合が40vol%以下では、得られる絶縁材料組成物の熱伝導率が3.0×10-3cal/cm･sec･℃に達しない。一方、85vol%を越えると、前記の表面処理を施しても、弾力性のある樹脂混合物が得られず、その硬化物もボロボロの状態なので、本発明の目的を達し得なくなる。50vol%以上70vol%以下の場合に、高熱伝導率で、しかも低比誘電率のバランスのとれた絶縁材料組成物を安定して製造することができる。

【００２７】導電箔３については、導体回路用銅箔、複合箔又は銅、アルミニウム、ニッケル等の金属を２種類以上含む合金又は前記金属を使用したクラッド箔等の汎

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用のものが用いられる。その厚みは、5μmから1mmである。又、ワイヤーボンディング特性を付与するためにニッケルメッキ、ニッケルー金メッキを導電箔上に施してもかまわない。

【0028】

【作用および実施例】以下、実施例について具体的に説明する。

（実施例1）窒化硼素粉（電気化学工業（株）製、GPS-2）をヘキサメチルジシラザン（東芝シリコーン（株）製）と混合してシリル化処理をした窒化硼素粉を作製した。このシリル化処理した窒化硼素粉を無機充填材として、ビスフェノールF型エポキシ樹脂に61vol%充填した混合物を作製した。この混合物にアミン系硬化剤を加え、加熱硬化して得た硬化物について、以下に示す熱伝導率測定と比誘電率測定を行った。次に、前記混合物を1.5mm厚みのアルミニウム板に塗布して厚さ100μmの層を形成し、更に、その上に厚さ35μmの銅箔を積層して加熱することで金属ベース回路基板を作製した。この回路基板を用いて、以下に示した放電開始電圧測定及びトランジスターの通電時の上昇温度測定を行った。又、回路基板の絶縁破壊寿命を調べるためにV－t特性の測定を繰り返し数20個にて実施した。得られた結果を表1に示す。

【0029】＜熱伝導率の測定方法＞厚さ2mm×直径10mmの円盤形の試験片を用い、レーザーフラッシュ法熱伝導率測定装置（理学電機工業（株）製「LF/TCM-FA-8510B」）により、ATTレンジ；20μV、サンプリングレート；1000μ秒、フィルター；100Hzで測定した。

【0030】＜比誘電率の測定方法＞JIS C6481に基づき、測定周波数100kHz、測定温度25℃で行った。

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【0031】＜放電開始電圧の測定方法＞作製した金属ベース基板上に、エッチング法により直径が20mmの円電極パターンを作製した。ベース金属部とパターン部との間の放電開始電圧を部分放電測定器（三菱電線工業（株）、QM-20）で、測定周波数100kHzで測定した。

【0032】＜トランジスター上昇温度の測定方法＞金属ベース基板の導電箔をエッチングして10×15mmのパッド部を形成し、この上にトランジスター（TO-220、（株）東芝製）をハンダ付けした。金属板面側を冷却しながら、トランジスターに100W通電してトランジスター上面での温度を測定した。

【0033】＜V－t特性の測定方法＞金属ベース基板上に、エッチング法によって直径が20mmの円電極パターンを作製し、ベース金属部とパターン部との間にAC半波2kVの電圧を印加した。測定は試験を促進するために125℃の環境下で行った。電圧印加開始から絶縁破壊に至るまでの時間を測定しワイブルプロット法により平均寿命を算出した。

【0034】（実施例2～9、比較例1～4）無機充填材として、市販のいろいろな粒度の窒化硼素、ダイアモンド、酸化ベリリウム、酸化アルミニウム等を準備し、表1に示す配合割合で、実施例1と同じ方法で、各種の絶縁材料組成物の硬化物を作製し、熱伝導率及び比誘電率を測定した。尚、一部のものでは、表面処理を施さないものも作製した。更に、前記絶縁材料組成物を用いて回路基板を作製し、実施例1と同様に、放電開始電圧測定、トランジスター上昇温度測定及びV－t特性測定を行った。結果を実施例1の結果とともに表1に示す。

【0035】

【表1】

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	No	樹脂の種類	無機充填材				表面処理剤	熱伝導率	比誘電率	放電開始電圧	平均破壊時間	トランジスター温度
			種類	GI値	平均粒径	充填率						
		-	-	-	μm	vol%	-	×10⁻³ cal/cm·sec·℃	-	kV	Hr.	℃
実施例	1	ビスフェノールF型エポキシ樹脂	窒化硼素	1.4	3.5	51	ヘキサメチルグアナミン	9.1	4.2	2.2	>10000	71
	2	ビスフェノールA型エポキシ樹脂	窒化硼素	1.6	3.5	55	エポキシシランカップリング	7.0	4.1	2.2	>10000	79
	3	ビスフェノールF型エポキシ樹脂	窒化硼素	1.4	4.0	50	エポキシシランカップリング	4.5	4.0	2.3	>10000	129
	4	ビスフェノールF型エポキシ樹脂	窒化硼素	1.5	3.0	45	エポキシシランカップリング	3.0	3.9	2.4	>10000	145
	5	ビスフェノールF型エポキシ樹脂	ダイアモンド	-	1.2	50	-	9.0	4.4	2.1	>10000	74
	6	ビスフェノールF型エポキシ樹脂	酸化ベリリウム	-	2.1	65	-	18.2	4.5	2.1	>10000	49
	7	ビスフェノールF型エポキシ樹脂	窒化硼素	2.0	8.7	72	エポキシシランカップリング	16.5	4.3	2.2	>10000	55
	8	ビスフェノールF型エポキシ樹脂	窒化硼素	1.8	13.6	81	アミノシラン	31.1	4.4	2.1	>10000	40
	9	ビスフェノールF型エポキシ樹脂	窒化硼素 ＊＋酸化ベリリウム	-	-	74	-	25.4	4.5	2.1	>10000	44
比較例	1	ビスフェノールF型エポキシ樹脂	酸化珪素	-	5.0	70	エポキシシランカップリング	2.2	3.7	2.5	>10000	>150
	2	ビスフェノールF型エポキシ樹脂	酸化アルミニウム	-	14.6	73	-	8.9	7.6	1.2	2100	75
	3	ビスフェノールF型エポキシ樹脂	窒化硼素	3.5	3.5	35	-	1.3	3.8	2.2	>10000	>150
	4	ビスフェノールF型エポキシ樹脂	窒化硅素	-	4.5	58	エポキシシランカップリング	4.9	5.6	1.7	2900	119

＊窒化硼素：酸化ベリリウム＝1：1（体積比）

【００３６】

【発明の効果】本発明によれば、熱伝導率が高く、しかも比誘電率が低く電気絶縁性に優れた絶縁材料組成物が得られ、又、放電開始電圧が高く長期信頼性に優れた回路基板及びモジュールを得ることができた。本発明の絶縁材料組成物は熱伝導率が高く、しかも比誘電率が低いので、半導体素子の封止材としても好適である。

【００３７】

【図面の簡単な説明】

【図１】本発明の金属ベース回路基板を用いたモジュールの断面図である。

1. 金属板
2. 絶縁層
3. 導電箔
4. ハンダ
5. セラミックスチップ部品
6. 半導体素子
7. 端子

【図１】